

L Number	Hits	Search Text	DB	Time stamp
1	56308	(surface near5 (termination or terminate or terminating or modification or modify or modifying))	USPAT; US-PGPUB	2004/11/16 10:59
2	224	((surface near5 (termination or terminate or terminating or modification or modify or modifying)) ) and (ALD or (atomic adj layer adj deposition))	USPAT; US-PGPUB	2004/11/16 10:59
3	30	((surface near5 (termination or terminate or terminating or modification or modify or modifying)) ) and (ALD or (atomic adj layer adj deposition))) and @ad<20001124	USPAT; US-PGPUB	2004/11/16 11:02
4	21	((((surface near5 (termination or terminate or terminating or modification or modify or modifying)) ) and (ALD or (atomic adj layer adj deposition))) and @ad<20001124) and plasma	USPAT; US-PGPUB	2004/11/16 11:02

US-PAT-NO: 6551399

DOCUMENT-IDENTIFIER: US 6551399 B1

TITLE: Fully integrated process for MIM capacitors using atomic layer deposition

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Abstract Text - ABTX (1):

A method and apparatus for fabricating a metal-insulator-metal capacitor by performing atomic layer deposition (ALD). A fully integrated process flow prevents electrode-dielectric contamination during an essential ex situ bottom electrode patterning step.

TITLE - TI (1):

Fully integrated process for MIM capacitors using atomic layer deposition

Brief Summary Text - BSTX (3):

The present invention relates generally to semiconductor technology and, more particularly, to a method and apparatus for manufacturing metal-insulator-metal capacitors using atomic layer deposition.

Brief Summary Text - BSTX (6):

One variant of CVD to deposit thinner layers is a process known as atomic layer deposition (ALD). ALD has its roots originally in atomic layer epitaxy, which is described in U.S. Pat. Nos. 4,058,430 and 4,413,022 and in an article titled "Atomic Layer Epitaxy" by Goodman et al., J. Appl. Phys. 60(3), Aug. 1, 1986; pp. R65-R80. Generally, ALD is a process

wherein conventional CVD processes are divided into single-monolayer depositions, wherein each separate deposition step theoretically reaches saturation at a single molecular or atomic monolayer thickness and, then, self-terminates.

Brief Summary Text - BSTX (7):

The deposition is an outcome of chemical reactions between reactive molecular precursors and the substrate (either the base substrate or layers formed on the base substrate). The elements comprising the film are delivered as molecular precursors. The desired net reaction is to deposit a pure film and eliminate "extra" atoms (molecules) that comprise the molecular precursors (ligands). In a standard CVD process, the precursors are fed simultaneously into the reactor. In an ALD process, the precursors are introduced into the reactor separately, typically by alternating the flow, so that only one precursor at a time is introduced into the reactor. For example, the first precursor could be a metal precursor containing a metal element M, which is bonded to an atomic or molecular ligand L to form a volatile molecule ML.sub.x. The metal precursor reacts with the substrate to deposit a monolayer of the metal M with its passivating ligand. The chamber is purged and, then, followed by an introduction of a second precursor. The second precursor is introduced to restore the surface reactivity towards the metal precursor for depositing the next layer of metal. Thus, ALD allows for single layer growth per cycle, so that much tighter thickness controls can be exercised over standard CVD process. The tighter controls allow for ultrathin films to be grown.

Brief Summary Text - BSTX (9):

Although currently manufactured MIM capacitors use CVD technology, none are known to have been fabricated by ALD. Since ALD has the ability to deposit continuous ultrathin films of conductive, semiconductive or insulating (dielectric) material on complicated geometries, yet retain good uniformity and conformity, ALD is attractive for fabricating MIM capacitors. The present invention is directed to providing the integration of ALD for the manufacture of MIM capacitors.

Brief Summary Text - BSTX (11):

A method and apparatus for depositing a first conductive layer by atomic layer deposition and depositing a sacrificial layer above the first conductive layer also by atomic layer deposition without exposing the first conductive layer to oxidation. A defined structure is then formed by removing portions of the first conductive and sacrificial layers. Next, the sacrificial layer is removed to expose the underlying first conductive layer without exposing the first conductive layer to oxidation. A dielectric layer is next deposited over the exposed first conductive layer by atomic layer deposition. To form a metal-insulator-metal (MIM) capacitor, the stack is completed by depositing a top conductive layer.

Drawing Description Text - DRTX (14):

FIG. 13 is a block diagram showing one reactor apparatus for performing ALD, as well as pretreating the surface of a layer prior to ALD, in order to fabricate an MIM capacitor practicing the present invention.

Detailed Description Text - DETX (2):

The practice of atomic layer deposition (ALD) to deposit

a film layer onto a substrate, such as a semiconductor wafer, requires separately introducing molecular precursors into a processing reactor. The ALD technique will deposit an ultrathin film layer atop the substrate. The term substrate is used herein to indicate either a base substrate or a material layer formed on a base substrate, such as a silicon substrate. The growth of the ALD layer follows the chemistries associated with chemical vapor deposition (CVD), but the precursors are introduced separately.

Detailed Description Text - DETX (3):

In an example ALD process for practicing the present invention, the first precursor introduced is a metal precursor comprising a metal element M bonded to atomic or molecular ligand L to make a volatile molecule ML.sub.x (the x, y and z subscripts are utilized herein to denote integers 1, 2, 3, etc.). It is desirable that the ML.sub.x molecule bond with a ligand attached to the surface of the substrate. An example ligand is a hydrogen-containing ligand, such as AH, where A is a nonmetal element bonded to hydrogen. Thus, the desired reaction is noted as  $AH + ML_{\text{sub}.x} \rightarrow AML_{\text{sub}.y} + HL$ , where HL is the exchange reaction by-product.

Detailed Description Text - DETX (4):

After the ML.sub.x precursor reacts with the surface and self-saturates to terminate the reaction, the remaining non-reacted precursor is removed, typically by allowing the carrier gas to purge the processing chamber. The second precursor is then introduced. Since the surface of the substrate contains the MA--L combination, the second precursor reacts with the L termination on the surface. In this example, the second

precursor is comprised of  $AH_{z/2}$ , with A being a nonmetal element. The hydrogen component is typically represented by  $H_2O$ ,  $NH_3$  or  $H_2S$ . The reaction  $ML + AH_{z/2} \rightarrow MAH + HL$  results in the desired additional element A being deposited as AH terminated sites and the ligand L is eliminated as a volatile by-product HL. The surface now has AH terminated sites, which restore the surface to have AH terminations. This restoration completes one ALD cycle, in which a monolayer of MA is deposited on the surface.

Detailed Description Text - DETX (5):

The present invention uses the ALD process to fabricate a metal-insulator-metal (MIM) capacitor on a semiconductor wafer, such as a silicon wafer. It is appreciated that one problem with a prior art technique (such as the generic CVD process) of forming capacitors on a wafer is in the oxidation of the bottom conductive layer of the capacitor. After deposition of the bottom conductive layer, pattern delineation (photolithographic patterning, etching, etc.) and/or cleaning steps can oxidize the surface of the bottom conductive layer (including, metal, metal nitride or semiconducting layer).

Detailed Description Text - DETX (6):

The extent of oxidation varies with the substrate and the cleaning process, but typically accounts for more than 10 Angstroms. The air exposure of the bottom conductor during pattern delineation, as well as some oxygen plasma ashing processes that are conventionally applied to remove photoresist, will oxidize the surface of the bottom electrode, which will interface with an overlying insulator material. Parasitic oxide in the metal-dielectric

interface is undesirable, since these low quality oxides do not contribute to the insulating properties of the MIM capacitor. Worse, the added thickness may reduce the capacitance value by making the effective dielectric thicker. In addition, these poorly defined oxides may interfere with surface activation of the following dielectric ALD film and deteriorate the insulating properties of the ALD dielectric film. Furthermore, where ultrathin film layers (of 50 Angstroms or less) are being grown by ALD, oxidized regions of 10 Angstroms have considerable more impact than film layers (of much higher thickness) grown by conventional CVD techniques. The present invention is practiced to remove or inhibit these deficiencies.

Detailed Description Text - DETX (7):

Referring to FIGS. 1-4, one embodiment for practicing the present invention is shown. In FIG. 1, a substrate 10 (again, substrate is used herein to refer to either a base substrate or a material film layer formed on a base substrate) is shown upon which ALD is performed. A first conductive layer, which is typically a metal (M1) layer, 11 is deposited by ALD. Typically, M1 layer 11 is comprised of a metal or metal nitride, including Ta, Ta.sub.x N, Ti, TiN or Al, which is used for constructing MIM capacitors. A typical example structure for a MIM is Ta.sub.x N/Al.sub.2 O.sub.3 /Ta.sub.x N stack on HSG (high surface area polysilicon grain) layer. Thus, substrate 10 can be HSG, while M1 layer 11 can be Ta.sub.x N. With ALD, M1 layer 11 is deposited to an approximate thickness, of 30-50 angstroms.

Detailed Description Text - DETX (8):

Subsequently, a sacrificial layer 12 is deposited overlying layer 11 by ALD.

	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1 [1 ]	Document ID	Issue Date	Pages	Title	Current OR	Current xRef	Retrieval Classif
1	<input type="checkbox"/>	<input checked="" type="checkbox"/>		US 6780704 B1	20040824	29	Conformal thin films over textured capacitor electrodes	438/239	257/E21.00 8; 257/E21.27 2; 257/E21.27 4; 257/E21.28 1; 438/240; 438/761; 438/765; 438/780; 438/790	
2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		US 6727169 B1	20040427	29	Method of making conformal lining layers for damascene metallization	438/622	438/641; 438/674	
3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		US 6689220 B1	20040210	21	Plasma enhanced pulsed layer deposition	118/695	118/698; 118/723E; 118/723I; 118/723MW	
4	<input type="checkbox"/>	<input checked="" type="checkbox"/>		US 6551399 B1	20030422	19	Fully integrated process for MIM capacitors using atomic layer deposition	117/102	117/105; 117/106; 117/89	
5	<input type="checkbox"/>	<input checked="" type="checkbox"/>		US 6503330 B1	20030107	13	Apparatus and method to achieve continuous interface and ultrathin film during atomic layer deposition	118/715	118/723ER; 118/723IR; 118/723ME	



	Inventor	S	C	P	2	3	4	5	Image Doc. Displayed	PT
1	Raaijmakers, Ivo et al.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6780704	<input type="checkbox"/>
2	Raaijmakers, Ivo et al.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6727169	<input type="checkbox"/>
3	Nguyen, Tue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6689220	<input type="checkbox"/>
4	Sneh, Ofer et al.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6551399	<input type="checkbox"/>
5	Sneh, Ofer et al.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6503330	<input type="checkbox"/>

	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Document ID	Issue Date	Pages	Title	Current OR	Current xRef	Retrieval Classif
6	<input type="checkbox"/>	<input checked="" type="checkbox"/>	US 6482262 B1	20021119	11	Deposition of transition metal carbides	117/84	117/88; 257/E21.17 1; 257/E21.58 4; 427/249.1; 427/249.17 ; 427/249.18 ; 427/249.19 ; 438/680; 438/685	
7	<input type="checkbox"/>	<input checked="" type="checkbox"/>	US 6475910 B1	20021105	11	Radical-assisted sequential CVD	438/685	118/715; 257/E21.17 ; 438/680	
8	<input type="checkbox"/>	<input checked="" type="checkbox"/>	US 6391785 B1	20020521	14	Method for bottomless deposition of barrier layers in integrated circuit metallization schemes	438/704	257/E21.17 1; 257/E21.57 9; 257/E21.58 2; 257/E21.58 4; 438/689	
9	<input type="checkbox"/>	<input checked="" type="checkbox"/>	US 6305314 B1	20011023	18	Apparatus and concept for minimizing parasitic chemical vapor deposition during atomic layer deposition	118/723R	118/723E; 257/E21.17 ; 257/E21.27 2; 257/E21.27 4	

	Inventor	S	C	P	2	3	4	5	Image Doc. Displayed	PT
6	Elers, Kai-Erik et al.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6482262	<input type="checkbox"/>
7	Sneh, Ofer	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6475910	<input type="checkbox"/>
8	Satta, Alessandra et al.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6391785	<input type="checkbox"/>
9	Sneh, Ofer et al.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6305314	<input type="checkbox"/>

	U	1 [1 ]	Document ID	Issue Date	Pages	Title	Current OR	Current xRef	Retrieval Classif
10	<input type="checkbox"/>	<input checked="" type="checkbox"/>	US 6200893 B1	20010313	11	Radical-assisted sequential CVD	438/685	117/92; 117/93; 257/E21.17 ; 427/255.39 4; 427/576; 427/578; 427/96.8; 438/677; 438/680	

	Inventor	S	C	P	2	3	4	5	Image Doc. Displayed	PT
10	Sneh, Ofer	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	US 6200893	<input type="checkbox"/>